THE INTERRELATIONSHIP OF THE NUMBER OF STAMENS AND PISTILS IN THE FLOWERS OF *FICARIA*.

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I. Introductory Remarks.

A survey of the rapidly increasing literature must convince anyone that the problem of the factors which determine the sex of the organism is one of such complexity that it cannot be solved on the basis of any one kind of material or by any one method of research.

In the flowering plants the same individual may produce both eggs and sperm. The relative numbers of egg and sperm producing organs may vary from individual to individual, or from flower to flower within the individual.

It is reasonable to assume that definite genetic, morphogenetic or physiological factors underlie these variations. Any successful attempt to determine these factors and to measure their influence is just as truly a contribution to the wide problem of the physiology of sex as the more conventional breeding experiments and studies on the morphology of the germ cells.

The purpose of this paper is to point out certain hitherto unrecognized relationships between the number of sporophylls in the flower of the ranunculaceous genus *Ficaria*.

Heretofore those who have investigated the problem of the relationship between the number of stamens and pistils in the flower have been content to merely determine the correlation between the number of the two kinds of spore-bearing organs. Positive correlations of this kind should arise as the resultant of any sets of environmental factors which tend to increase both the number of stamens and the number of pistils in certain of the plants or individual flowers and to limit the number of both of these organs in others. Morphogenetically and physiologically it seems of far greater importance to inquire whether the relative

proportion of the two types of spore bearing organs is correlated with the total number of sporophylls, which in lieu of any better character may serve as a measure of the total influence of intrinsic and extrinsic factors influencing degree of development.

Several years ago Professor Pearson and I (Harris, '09) showed that problems of this kind can be approached by determining the correlation between the total organs laid down and the deviation of the number of a particular kind from the probable number on the assumption that the proportion of the particular kind is independent of the total number.

The statistical method may of course be applied to experimental data or to series of determinations made on organisms developing under natural conditions. As yet experimental series are not available.

In a former paper ('16) I showed that in the inflorescences of both *Arisarum vulgare* and *A. proboscidium* there is a significant negative correlation between the total number of flowers and the deviation of the number of staminate flowers from their probable number on the theory of proportional distribution. Thus the male flowers while *absolutely* more numerous in the inflorescences with larger total numbers of flowers are *relatively* less numerous than in the inflorescences with smaller total numbers of flowers. Or, conversely, the larger inflorescences tend to produce *a larger proportion* of pistillate flowers.

In this paper the same analytical methods will be applied to the problem of the relationship of the number of stamens and the number of pistils to the total number of stamens and pistils produced by the flower.

II. Materials.

The materials upon which the coefficients discussed in this paper are based have been tabled and the chief biometric constants deduced by competent statisticians. The special methods upon which the conclusions of this paper are based were not, however, available at the time their calculations were made. The results are, therefore, quite new.

The series employed are the following:

1–2. A series of 283 countings of number of stamens and

pistils of *Ficaria verna* from Trogen and another series of 80 countings from Gais, published by Ludwig ('01). Statistical constants for both of these series have been deduced and published by Dr. Alice Lee ('02).

3–4. A series of 268 early and 373 late flowers of *Ficaria ranunculoides* collected by MacLeod ('99) and discussed by W. F. R. Weldon ('01).

5–8. Four series of *Ficaria ranunculoides* collected by Galton, Weldon, Pearson ('03) and others in Italy, Guernsey and England.

III. Presentation of Data.

The means and variabilities of number of stamens and pistils per flower have been given in the papers cited. The only point which requires discussion in this place is the relative variability of the number of the two types of sporophylls. This is shown in Table I.

Table I.

Relative Variabilities in Number of Stamens and Number of Pistils in *Ficaria.*

Series.	Number of Flowers.	Coefficient of Variation for Pistils.	Coefficient of Variation for Stamens.	Differences
Switzerland—				
Trogen, I	283	23.32	18.68	4.64
Gais, II	80	23.73	12.18	11.55
Belgium—				
Early, III	268	23.32	14.07	9.25
Late, IV	373	27.89	18.46	9.43
Italy, V	624	22.35	14.12	8.23
Guernsey, VI	520	26.54	17.16	9.38
England—				
Dorset, VII	505	26.38	16.84	9.54
Surrey, VIII	500	27.19	17.32	9.87

The number of pistils is consistently more variable than the number of stamens.

Other workers have shown that there is a correlation of medium intensity between the number of stamens and the number of pistils per flower. Their constants, all of which have been rechecked in the course of this work, are shown in Table II. I have also added the linear regression equations showing the rate of increase in mean number of pistils associated with an increase in the number of stamens and the rate of increase in

Table II.

Correlation between Number of Stamens and Pistils in *Ficaria* and Regression Equations for Stamens and Pistils.

Series.	Number of Flowers.	Correlation Stamens and Pistils.	Ratio of Correlation to Probable Error r/E_r.	Regression Line.
Switzerland—				
Trogen	283	.530 ± .029	18.27	$S = 11.708 + .645P$
				$P = 4.461 + .429S$
Gais	80	.388 ± .064	6.06	$S = 19.075 + .262P$
				$P = 4.403 + .575S$
Belgium—				
Early	268	.507 ± .031	16.35	$S = 18.197 + .489P$
				$P = 3.427 + .525S$
Late	373	.749 ± .015	49.93	$S = 9.006 + .729P$
				$P = -1.593 + .769S$
Italy	624	.439 ± .022	19.95	$S = 19.313 + .418P$
				$P = 5.409 + .460S$
Guernsey	520	.534 ± .021	25.43	$S = 18.302 + .404P$
				$P = 4.160 + .707S$
England—				
Dorset	505	.669 ± .017	39.35	$S = 20.369 + .535P$
				$P = -1.333 + .835S$
Surrey	500	.660 ± .017	38.82	$S = 19.091 + .588P$
				$P = -.860 + .741S$

mean number of stamens associated with an increase in number of pistils per flower.

The regression of the number of stamens on the number of pistils and of the number of pistils on the number of stamens is shown for three of the larger series in Figs. 1–3.

The empirical means for the Italian series, Diagram 1, do not conform very satisfactorily to the lines given by the equations. Better agreements between actual and theoretical means could hardly be found (in series of data no larger than these) than in the Guernsey and Surrey series represented in Figs. 2 and 3.

The main purpose of the present paper is to present the results of the determination of the relationship between the total number of sporophylls and the number of stamens and pistils.

The correlations between the total number of sporophylls and the number of stamens and pistils are shown in Table III.

As is to be expected the correlations between total sporophylls and number of stamens and pistils are high.

The constants showing the relationship between the total number of sporophylls and the deviation of the number of

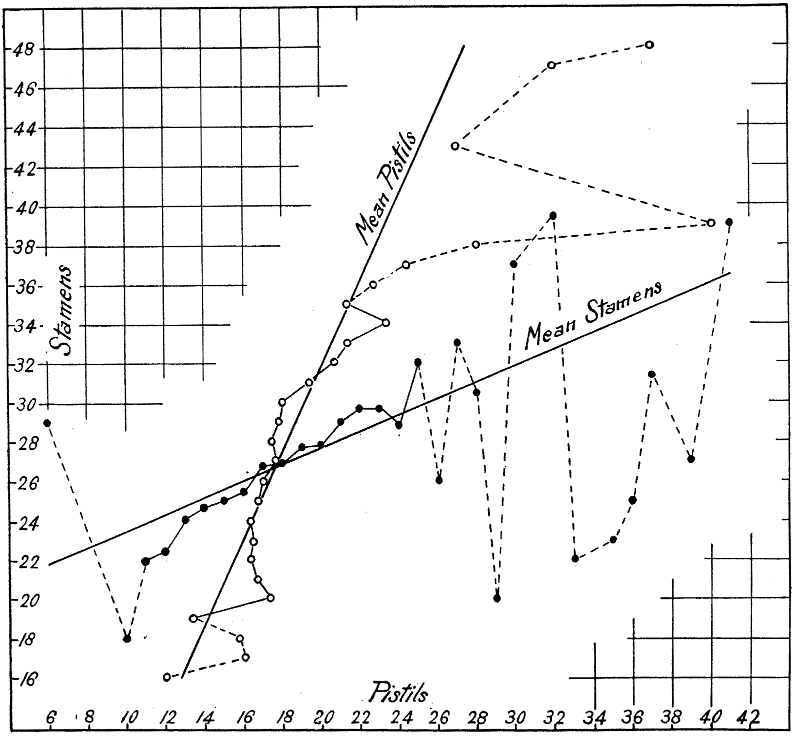

FIG. 1. Average numbers of stamens in flowers with various numbers of pistils and average numbers of pistils in flowers with various numbers of stamens. Empirical and smoothed values. Italian series.

TABLE III.

CORRELATION BETWEEN TOTAL SPOROPHYLLS AND NUMBER OF STAMENS AND PISTILS AND BETWEEN TOTAL SPOROPHYLLS AND DEVIATION OF THE NUMBER OF STAMENS AND PISTILS FROM THEIR PROBABLE VALUE.

Series.	Correlation Between Sporophylls and Stamens.	r_{sz_s}.[1]	r/E_r.	Correlation Between Sporophylls and Pistils.	r_{sz_p}.[2]
I.	.901 ± .008	− .139 ± .039	3.52	.845 ± .012	+.139 ± .039
II.	.755 ± .032	− .548 ± .053	10.37	.896 ± .015	+.548 ± .053
III.	.862 ± .011	− .378 ± .035	10.69	.873 ± .010	+.378 ± .035
IV.	.933 ± .005	− .477 ± .027	17.74	.936 ± .004	+.477 ± .027
V.	.840 ± .008	− .354 ± .024	14.99	.855 ± .007	+.354 ± .024
VI.	.836 ± .009	− .433 ± .024	18.04	.910 ± .005	+.433 ± .024
VII.	.892 ± .027	− .487 ± .023	21.37	.932 ± .004	+.487 ± .023
VIII.	.900 ± .006	− .463 ± .024	19.64	.921 ± .005	+.463 ± .024

[1] Correlation between sporophylls and deviation of stamens from their probable value.

[2] Correlation between sporophylls and deviation of pistils from their probable value.

macro- and the number of microsporophylls from their probable value are the coefficients of critical value. These are also given in Table III. The correlations for stamens and pistils are necessarily equal in magnitude but opposite in sign. They show that the number of pistils is relatively larger in the flowers with larger numbers of sporophylls. The results are consistent in sign throughout. All of the correlations except that for the series from Trogen may be considered certainly significant in comparison with their probable errors.

While the constants for certain of the series differ significantly, the results are (considering the relatively small numbers and the very wide geographical distribution of the material) very consistent. Five of the eight series differ from $r = \pm .50$ by less than twice their probable error. Of the other three series, only Professor Ludwig's Trogen material is very aberrant.

For two of the series I have determined the standard devia-

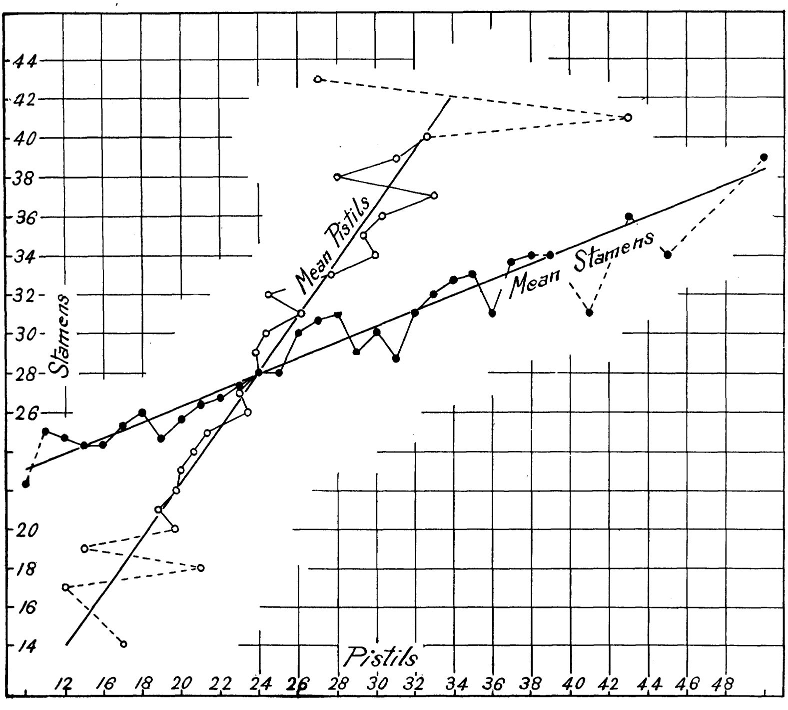

FIG. 2. Empirical means and regression straight lines for regression of stamens on pistils and pistils on stamens. Guernsey series.

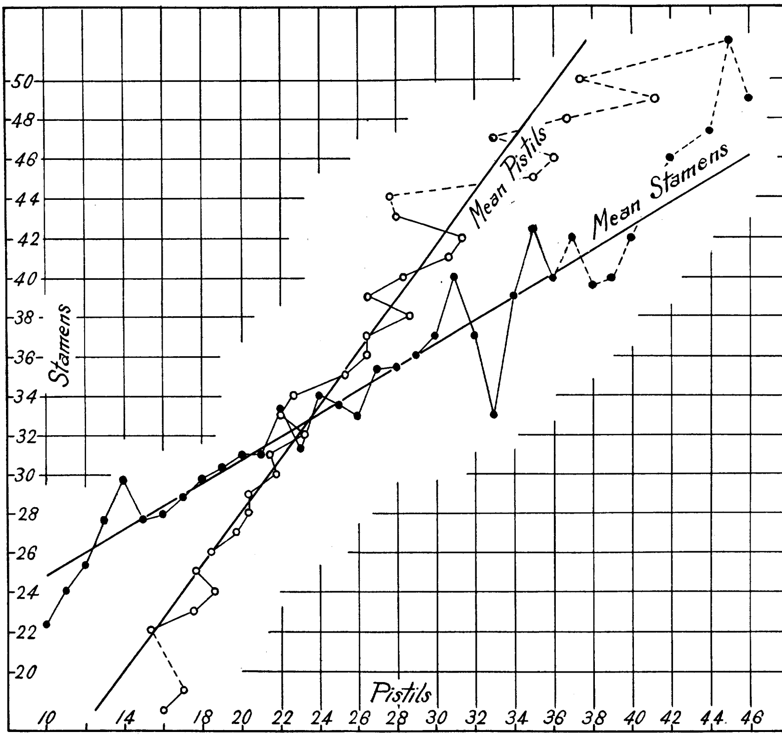

FIG. 3. Explanation as in Figs. 1 and 2. English series.

tion of the deviation of the number of stamens (or pistils) from their probable value by a formula to be published shortly ('17). They are:

For Bordighera, $\sigma_z = 2.1873$

For Surrey, $\sigma_z = 2.8054$

These values make possible the determination of the straight line equations showing the regression of the deviation of the number of stamens and pistils from their probable values upon the total number of sporophylls. They are:

For Bordighera series— $Z_s = + 5.2446 - .1181\ S$

$Z_p = - 5.2446 + .1181\ S$

For Surrey series— $Z_s = + 6.6565 - .1179\ S$

$Z_p = - 6.6565 + .1179\ S$

Here Z_s and Z_p denote the deviations of the stamens and pistils from their probable values and S denotes the total number of sporophylls.

The results are represented graphically in Figs. 4 and 5. In the Italian series, flowers with fewer than 36 stamens and pistils are only 29 in number, distributed among flowers with from 28–35 sporophylls per flower. The means at this end of the range cannot, therefore, be expected to show great regularity.

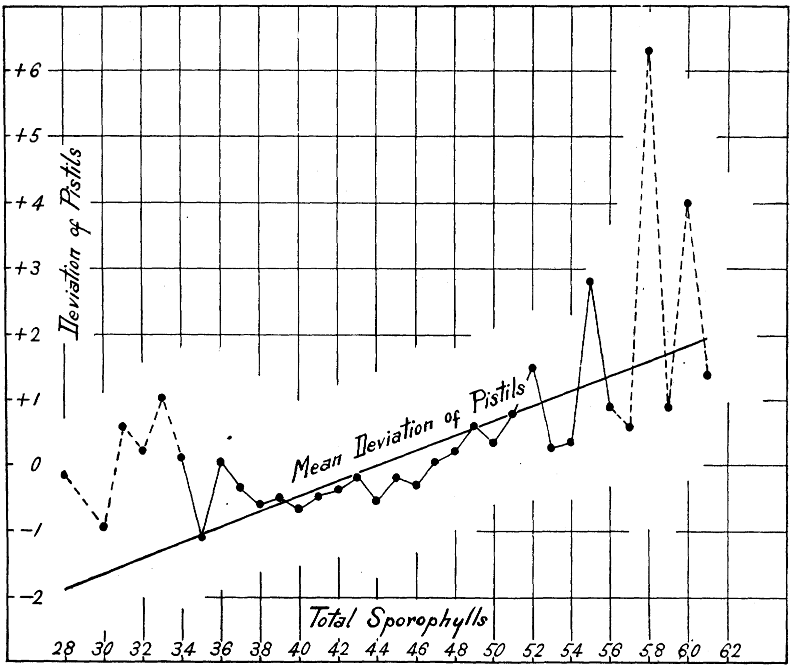

FIG. 4. Regression of the deviation of the total number of pistils from their probable value on the total number of sporophylls. Italian series.

Flowers with more than 61 sporophylls are only 10 in number but are distributed among flowers ranging from 62–85 sporophylls per flower. This portion of the range has not been included in Fig. 4. The relationship is apparently not quite linear.

In the material from Surrey, shown in Fig. 5, the increase in the relative proportion of pistils associated with increase in the total number of stamens and pistils could hardly be better represented than by the slope of the straight line indicated by the equation.

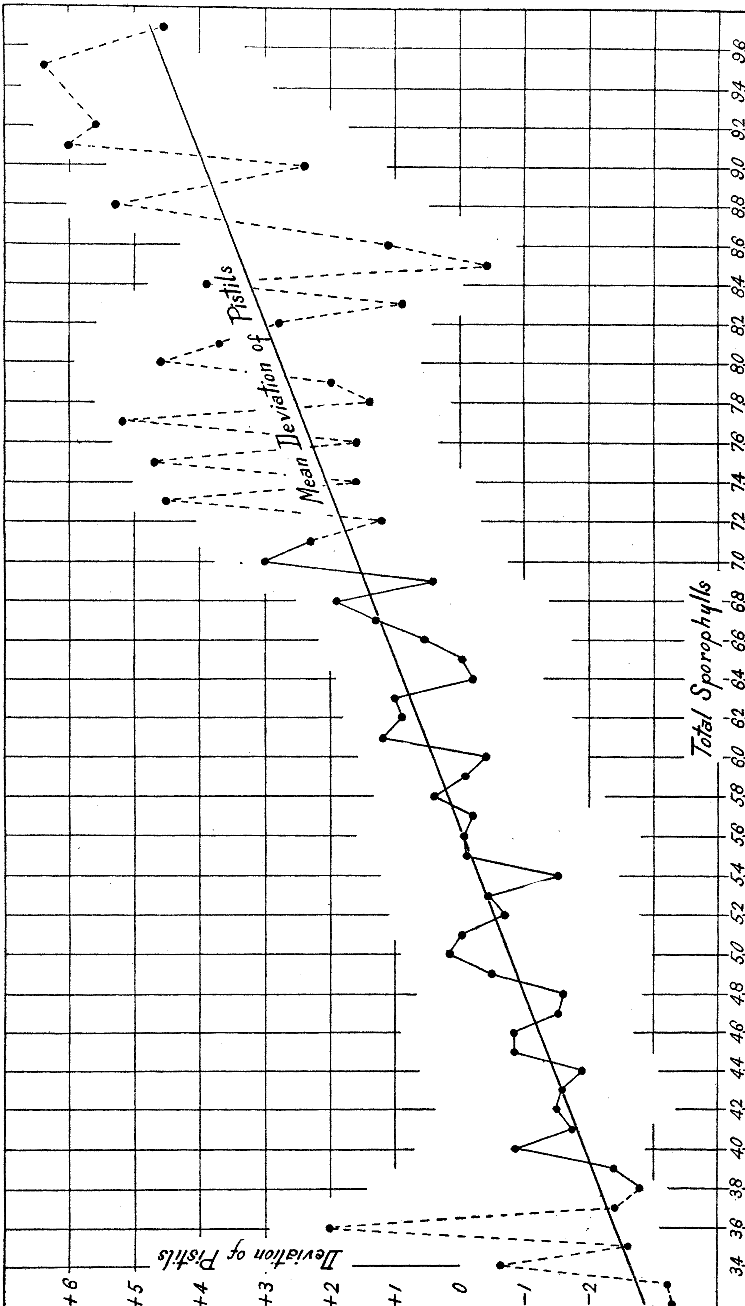

FIG. 5. Regression of the deviation of the total number of pistils from their probable value on the total number of sporophylls. Surrey material.

IV. Recapitulation.

The present study deals with the problem of the relationship between the total number of sporophylls laid down and the relative number of stamens and pistils in the ranunculaceous genus *Ficaria*.

Constants have been deduced for eight series of published data from Italy, Switzerland, Belgium, Guernsey and England not hitherto analyzed by the methods now available.

In flowers with larger numbers of sporophylls the pistils are relatively more numerous than the stamens. The high degree of consistency of the results drawn from such a wide range of habitats indicates that the relationship is one of real morphogenetic significance.

In an earlier paper it has been shown that in *Arisarum* the relative number of pistillate flowers increases as the total number of flowers becomes larger.

It is at least suggestive in relation to the problem of the physiology of sex that in both of these very different forms the number of macrosporophylls becomes relatively larger as the total number of sporophylls increases. The relationships may, however, have an embryological explanation. Only further investigations will justify final conclusions concerning the cause of the relationship demonstrated.

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